Form C: Type Test Verification Report

All Micro-generators connected to the **DNO Distribution Network** shall be **Fully Type Tested**. This form is the **Manufacturer**'s declaration of compliance with the requirements of EREC G98.

This form should be used when making a Type Test submission to the Energy Networks Association (ENA) Type Test Register.

If the **Micro-generator** is **Fully Type Tested** and already registered with the ENA Type Test Register, the **Installation Document** should include the **Manufacturer**'s Reference Number (the system reference), and this form does not need to be submitted.

Manufacture	r's referenc	e number	TSI-5K3D, TSI-6K3D, TSI-8K3D, TSI-10K3D; TSI-6K3A, TSI-8K3A, TSI-10K3A				
Micro-gener	ator technol	ogy	Grid Support Hybrid Inverter				
Manufacturer name		Tigo Energy					
Address			655 Campbell	Technology Pa	arkway Ste 150, Campbell, CA 95008		
Tel	(408) 402-0	0802		Fax			
E-mail	Bijay.Shres	stha@tigoen	ergy.com	Web site	http://www.tigoenergy.com/		
Registered Capacity, use separate sheet ifConnection		n Option	Option				
		5	kW three phase				
more than on connection of		6	kW three phase				
		8	kW three phase				
		10	kW three phas	se			
		NA	kW single pha	ise, single, split	or three phase system		
		NA	kW two phase	es in three phase	e system		
		NA	kW two phases split phase system				
Energy storag			11.5kWh, 17.3kWh, 23.0kWh, 34.6kWh, 46.1kWh;				
capacity for Electricity Storage devices		6.1kWh, 9.2kWh, 12.3kWh					
Type Tested	Manufacturer Type Test declaration I certify that all products supplied by the company with the above Fully Type Tested reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the product meets						

all the requirements of EREC G98.

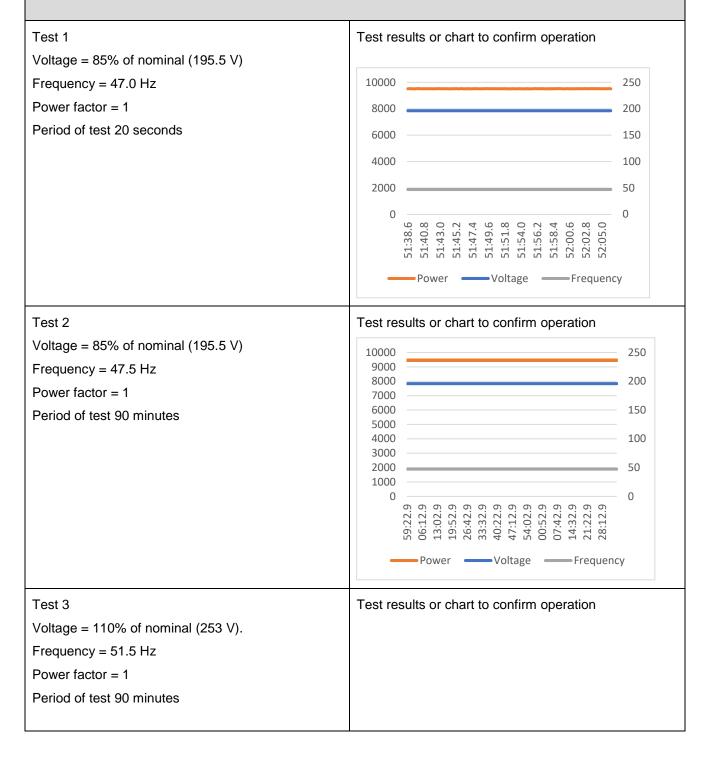
Signed	Bijay Shiwastan	On behalf of	Tigo Energy
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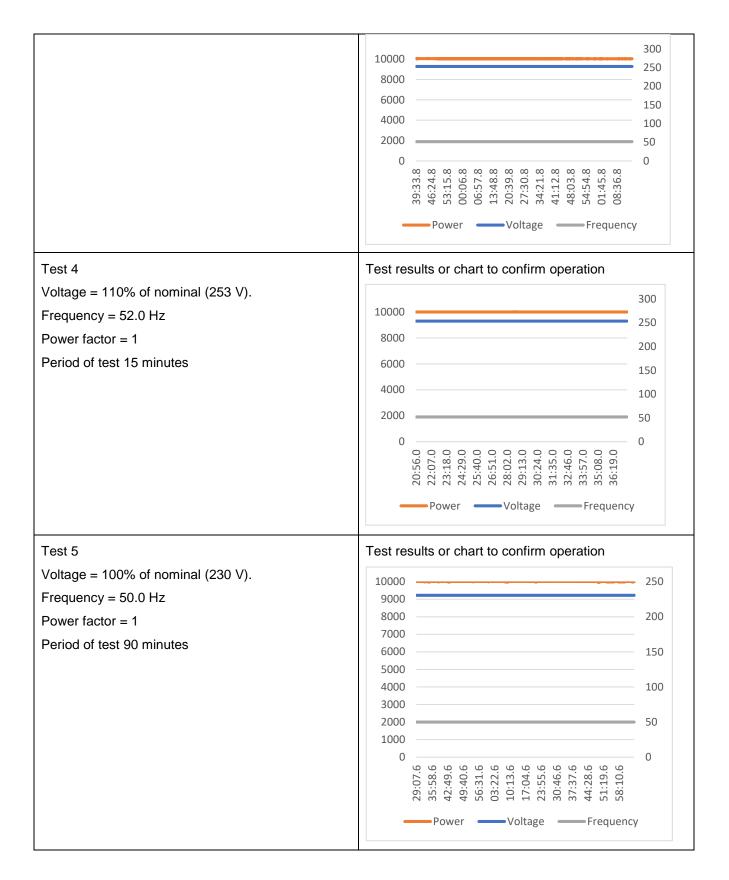
Note that testing can be done by the Manufacturer of an individual component or by an external test house.

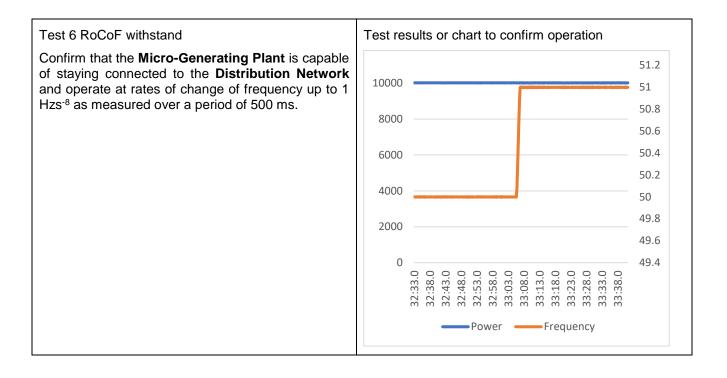
Where parts of the testing are carried out by persons or organisations other than the **Manufacturer** then that person or organisation shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.

Operating Range: This test should be carried out as specified in A.1.2.10.

Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement "Pass", "No disconnection occurs", etc. Graphical evidence is preferred.







Power Quality – Harmonics: These tests should be carried out as specified in BS EN 61000-3-2. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of **Registered Capacity**. The test requirements are specified in Annex A1 A.1.3.1 (**Inverter** connected) or Annex A2 A.2.3.1 (Synchronous).

	Micro-generator tested to BS EN 61000-3-2										
	Micro-ę	generator r	ating per pl	nase (rpp)		3.3	kW				
For 3-pha identical fo please rep	or all three										
Harmonic At 45-55% of Registered 100% of Registered Capacity Capacity ¹ 100% of Registered Capacity											
	Measure	ed Value M	√ in Amps	Measure	′ in Amps	Limit in BS EN 61000-3- 2 in Amps	Higher limit for odd harmonics 21 and above				
	L1	L2	L3	L1	L2	L3					
2	0.007	0.005	0.008	0.009	0.009	0.007	1.080				
3	0.008	0.006	0.009	0.011	0.008	0.009	2.300				
4	0.006	0.004	0.007	0.008	0.006	0.010	0.430				
5	0.019	0.015	0.020	0.026	0.025	0.026	1.140				
6	0.005	0.005	0.005	0.009	0.006	0.014	0.300				
7	0.017	0.020	0.017	0.017	0.016	0.017	0.770				
8	0.006	0.004	0.005	0.005	0.006	0.008	0.230				
9	0.004	0.007	0.006	0.008	0.006	0.007	0.400				
10	0.004	0.005	0.005	0.006	0.007	0.010	0.184				
11	0.014	0.014	0.015	0.018	0.017	0.018	0.330				
12	0.007	0.006	0.007	0.005	0.005 0.005 0.008						
13	0.014	0.015	0.014	0.012	0.011	0.013	0.210				
14	0.004	0.004	0.005	0.007	0.006	0.007	0.131				
15	0.008	0.006	0.007	0.007	0.006	0.006	0.150				

¹ See the note in A.2.3.1 if 45-55% of **Registered Capacity** is below the minimum stable operating level. If an alternative loading level is chosen, the level should be indicated on the test form and the reason for not testing at 45-55% of **Registered Capacity** should be stated. The additional comments box at the end of the harmonics test sheet can be used for this.

16 0	0.006	0.006	0.008	0.006	0.006	0.007	0.115	
17 0	0.013	0.015	0.009	0.012	0.013	0.015	0.132	
18 0	0.007	0.007	0.005	0.006	0.006	0.007	0.102	
19 0	0.005	0.006	0.007	0.011	0.013	0.012	0.118	
20 0	0.006	0.006	0.007	0.006	0.007	0.006	0.092	
21 0	0.005	0.008	0.006	0.005	0.006	0.005	0.107	0.160
22 0	0.004	0.005	0.005	0.009	0.006	0.006	0.084	
23 0	0.005	0.005	0.004	0.007	0.006	0.008	0.098	0.147
24 0	0.003	0.003	0.005	0.006	0.005	0.008	0.077	
25 0	0.005	0.005	0.006	0.013	0.014	0.013	0.090	0.135
26 0	0.005	0.003	0.005	0.009	0.009	0.007	0.071	
27 0	0.003	0.003	0.003	0.008	0.006	0.008	0.083	0.124
28 0	0.004	0.003	0.004	0.016	0.014	0.012	0.066	
29 0	0.007	0.005	0.008	0.009	0.009	0.007	0.078	0.117
30 0	0.008	0.006	0.009	0.011	0.008	0.009	0.061	
31 0	0.006	0.004	0.007	0.008	0.006	0.010	0.073	0.109
32 0	0.019	0.015	0.020	0.026	0.025	0.026	0.058	
33 0	0.005	0.005	0.005	0.009	0.006	0.014	0.068	0.102
34 0	0.017	0.020	0.017	0.017	0.016	0.017	0.054	
35 0	0.006	0.004	0.005	0.005	0.006	0.008	0.064	0.096
36 0	0.004	0.007	0.006	0.008	0.006	0.007	0.051	
37 0	0.004	0.005	0.005	0.006	0.007	0.010	0.061	0.091
38 0	0.014	0.014	0.015	0.018	0.017	0.018	0.048	
39 0	0.007	0.006	0.007	0.005	0.005	0.008	0.058	0.087
40 0	0.014	0.015	0.014	0.012	0.011	0.013	0.046	

Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

Additional comments:

Power Quality – Voltage fluctuations and Flicker: These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (**Inverter** connected) or Annex A2 A.2.3.3 (Synchronous).

The standard test impedance is 0.4 Ω for a single phase **Micro-generating Plant** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Micro-generating Plant** (and for a two phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):

d max normalised value = (Standard impedance / Measured impedance) x Measured value.

Where the **Power Factor** of the output is under 0.98 then the X to R ratio of the test impedance should be close to that of the standard impedance.

The stopping test should be a trip from full load operation.

The duration of these tests needs to comply with the particular requirements set out in the testing notes for the technology under test.

The test date and location must be declared.

Test start date	20.5.2022		Test end date 20.5.2		2022				
Test location		o. 288 Shizhu Road, Tonglu Economic Development Zone, Tonglu City, Zhejiang Province 10000, P.R. China							
	Starting			Stopping				Running	
	d(max)	d(c)	d(t)	d(max)	d(c)	(d(t)	Pst	P _{lt} 2 hours
Measured Values at test impedance	0.7811	0.1787	0	0.8242	0.1380) (0	0.249	0.170
Normalised to standard impedance	NA	NA	NA	NA	NA	1	NA	NA	NA
Normalised to required maximum impedance	NA	NA	NA	NA	NA	1	NA	NA	NA
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	;	3.3%	1.0	0.65
Test Impedance	R			Ω	>	K			Ω

Standard Impedance	R	0.24 * 0.4 ^	Ω	х	0.15 * 0.25 ^	Ω
Maximum Impedance	R		Ω	х		Ω

*Applies to three phase and split single phase **Micro-generators**. Delete as appropriate.

^ Applies to single phase **Micro-generators** and **Micro-generators** using two phases on a three phase system. Delete as appropriate.

Power quality – DC injection: This test should be carried out in accordance with A 1.3.4 as applicable.

The % **DC** injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / base current

where the base current is the **Registered Capacity** (W) / 230 V. The % **DC** injection should not be greater than 0.25%.

Test power level	20%	50%	75%	100%
Recorded DC value in Amps	0.0265/0.0214/0.021 6	0.0065/0.0085/0.007 2	0.0065/0.0146/0.0119	0.0092/0.0133/0.0152
as % of rated AC current	0.18%/0.15%/0.15%	0.04%/0.06%/0.05%	0.04%/0.10%/0.08%	0.06%/0.09%/0.10%
Limit	0.25%	0.25%	0.25%	0.25%

Power Quality – Power factor: This test shall be carried out in accordance with A.1.3.2 and A.2.3.2 at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within $\pm 1.5\%$ of the stated level during the test.

	216.2 V	230 V	253 V
Measured value	0.9999	0.9998	0.9999
Power Factor Limit	>0.95	>0.95	>0.95

Protection – Frequency tests: These tests should be carried out in accordance with Annex A1 A.1.2.3 (**Inverter** connected) or Annex A2 A.2.2.3 (Synchronous). For trip tests, frequency and time delay should be stated. For "no trip tests", "no trip" can be stated.

Function	Setting		Trip test		"No trip tests"		
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip	
U/F stage 1	47.5 Hz	20 s	47.49Hz	20.1s	47.7 Hz 30 s	No trip	
U/F stage 2	47 Hz	0.5 s	47.01Hz	0.598s	47.2 Hz 19.5 s	No trip	

					46.8 Hz 0.45 s	No trip
O/F stage 1	52 Hz	0.5 s	52.01 Hz	0.51s	51.8 Hz 120.0 s	No trip
					52.2 Hz 0.45 s	No trip

Note. For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The "No trip tests" need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Protection – Voltage tests: These tests should be carried out in accordance with Annex A1 A.1.2.2 (**Inverter** connected) or Annex A2 A.2.2.2 (Synchronous). For trip tests, voltage and time delay should be stated. For "no trip tests", "no trip" can be stated.

	1		1				
Function	Setting		Trip test		"No trip tests"		
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip	
U/V	184 V	2.5 s	183.6V	2.52 s	188 V 5.0 s	No trip	
					180 V 2.45 s	No trip	
O/V stage 1	262.2 V	1.0 s	261.9V	1.01 s	258.2 V 5.0 s	No trip	
O/V stage 2	273.7 V	0.5 s	273.5V	0.572s	269.7 V 0.95 s	No trip	
					277.7 V 0.45 s	No trip	

Note for Voltage tests the Voltage required to trip is the setting ± 3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ± 4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Protection – Loss of Mains test: For PV **Inverters** shall be tested in accordance with BS EN 62116. Other **Micro-generators** should be tested in accordance with A.2.2.4 at 10%, 55% and 100% of rated power.

For Inverters tested to BS EN 62116 the following sub set of tests should be recorded in the following table.

Test Power and	33%	66%	100%	33%	66%	100%
imbalance	-5% Q	-5% Q	-5% P	+5% Q	+5% Q	+5% P
	Test 22	Test 12	Test 5	Test 31	Test 21	Test 10
Trip time. Limit is 0.5 s ²	0.376 s	0.448 s	0.118 s	0.391 s	0.410 s	0.440 s

² If the device requires additional shut down time (beyond 0.5 s but less than 1 s) then this should be stated on this form.

Protection – Frequency change, Vector Shift Stability test: This test should be carried out in accordance with EREC G98 Annex A1 A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the **Micro-generating Plant** does not trip under positive / negative vector shift.

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0 Hz	+50 degrees	No trip
Negative Vector Shift	50.0 Hz	- 50 degrees	No trip

Protection – Frequency change, RoCoF Stability test: The requirement is specified in section 11.3, test procedure in Annex A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the **Micro-generating Plant** does not trip for the duration of the ramp up and ramp down test.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip	
49.0 Hz to 51.0 Hz	+0.95 Hzs ⁻¹	2.1 s	No trip	
51.0 Hz to 49.0 Hz	-0.95 Hzs ⁻¹	2.1 s	No trip	

Limited Frequency Sensitive Mode – Overfrequency test: This test should be carried out in accordance with A.1.2.8. The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%. The measurement tolerances are contained in A.1.2.8.

Test sequence at Registered Capacity >80%	Measured Active Power Output	Frequency	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	10000.6W	50.00Hz		-
Step b) 50.45 Hz ±0.05 Hz	9979.3W	50.45 Hz		-
Step c) 50.70 Hz ±0.10 Hz	9544.5W	50.70 Hz		-
Step d) 51.15 Hz ±0.05 Hz	8546.3W	51.15 Hz		-
Step e) 50.70 Hz ±0.10 Hz	9544.0W	50.70 Hz		-
Step f) 50.45 Hz ±0.05 Hz	9980.6W	50.45 Hz		-
Step g) 50.00 Hz ±0.01 Hz	10032.3W	50.00 Hz		
Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output	Frequency	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	4972.5 W	50.00 Hz		-

Step b) 50.45 Hz ±0.05 Hz	4912.7 W	50.45 Hz
Step c) 50.70 Hz ±0.10 Hz	4357.3 W	50.70 Hz
Step d) 51.15 Hz ±0.05 Hz	3363.9 W	51.15 Hz
Step e) 50.70 Hz ±0.10 Hz	4362.9 W	50.70 Hz
Step f) 50.45 Hz ±0.05 Hz	4362.9 W	50.45 Hz
Step g) 50.00 Hz ±0.01 Hz	4974.2 W	50.00 Hz

Power output with falling frequency test: This test should be carried out in accordance with A.1.2.7.

Test sequence	Measured Active Power Output	Frequency	Primary power source
Test a) 50 Hz ± 0.01 Hz	10030W	50.00Hz	
Test b) Point between 49.5 Hz and 49.6 Hz	10031W	49.55Hz	
Test c) Point between 47.5 Hz and 47.6 Hz	10029W	47.55Hz	

NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes

Re-connection timer.

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 2. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Micro-generating Plant** does not reconnect at the voltage and frequency settings below; a statement of "no reconnection" can be made.

Time delay setting	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 2.				
60s	61s	At 266.2 V	At 180.0 V	V	At 47.4 Hz	At 52.1 Hz
	irmation that the o-generator does No-Reconnection No-Reconnection e-connect.		No-Reconnection	No-Reconnection		
Fault level contribution : These tests shall be carried out in accordance with EREC G98 Annex A1 A.1.3.5 (Inverter connected) and Annex A2 A.2.3.4 (Synchronous). Please complete each entry, even if the fault contribution is zero.						
For machines with electro-magnetic output For Inverter output						

Parameter	Symbol	Value	Time after fault	Volts	Amps	
Peak Short Circuit current	i _p		20 ms	31.6V	3.65A	
Initial Value of aperiodic current	А		100 ms	25.0V	0.11A	
Initial symmetrical short-circuit current*	I _k		250 ms			
Decaying (aperiodic) component of short circuit current*	i _{DC}		500 ms			
Reactance/Resistance Ratio of source*	×/ _R		Time to trip	0.39s	In seconds	
For rotating machines and linear current as seen at the Micro-gen			st should produc	ce a 0 s – 2 s plo	t of the short circuit	
* Values for these parameters sh interpolation of the plot	ould be provi	ided where t	the short circuit	duration is suffici	ently long to enable	
Logic Interface (input port)						
Confirm that an input port is prov to zero	t Yes					
Provide high level description of le (the additional comments box be	l Yes					
Self-Monitoring solid state sw G98 Annex A1 A.1.3.6 (Inverter	NA NA					
It has been verified that in the event the Micro-generator , the voltage value below 50 V within 0.5 s.						
Cyber security						
Confirm that the Manufacturer statement describing how the M security requirements, as detailed						
Additional comments						